Standard Test Method for 
Fuel Injector Shear Stability Test (FISST) for Polymer 
Containing Fluids™

This standard is issued under the fixed designation D 5275; the number immediately following the designation indicates the year of 
original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A 
superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope^ε

1.1 This test method measures the percent viscosity loss at 
100°C of polymer-containing fluids using fuel injector shear 

stability test (FISST) equipment. The viscosity loss reflects 
polymer degradation due to shear at the nozzle.

NOTE 1—Test Method D 2603 has been used for similar evaluation of 
this property. It has many of the same limitations as indicated in the 
significance statement. No detailed attempt has been undertaken to 
correlate the results by the sonic and the diesel injector methods. 
Equipment and replacement parts are no longer available for Test Method 
D 2603 as it is currently written. The test method is currently under 
revision.

NOTE 2—This test method was originally published as Procedure B of 
Test Methods D 3945. The FISST method was made a separate test 
method after tests of a series of polymer-containing fluids showed that 
Procedures A and B of Test Methods D 3945 often give different results.

1.2 The values given in SI units are to be regarded as the 
standard. The inch-pound units given in parentheses are for 
information only.

1.3 This standard does not purport to address all of the 
safety concerns, if any, associated with its use. It is the 
responsibility of the user of this standard to establish appro-

priate safety and health practices and determine the applica-
bility of regulatory limitations prior to use. Specific precau-

tionary statements are given in Section 7.

2. Referenced Documents

2.1 ASTM Standards: ²
D 445 Test Method for Kinematic Viscosity of Transparent 
and Opaque Liquids (and the Calculation of Dynamic 
Viscosity)
D 2603 Test Method for Sonic Shear Stability of Polymer-

Containing Fluids
D 3945 Test Methods for Shear Stability of Polymer-

Containing Fluids Using a Diesel Injector Nozzle³

3. Summary of Test Method

3.1 The polymer-containing fluid is passed through a diesel 
injector nozzle at a shear rate that causes the less shear stable 
polymer molecules to degrade. The resultant degradation 
reduces the kinematic viscosity of the fluid under test. The 
reduction in kinematic viscosity, reported as percent loss of the 
initial kinematic viscosity, is a measure of the shear stability of 
the polymer-containing fluid.

4. Significance and Use

4.1 This test method evaluates the percent viscosity loss for 
polymer-containing fluids resulting from polymer degradation 
in the high shear nozzle device. Minimum interference from 
thermal or oxidative effects are anticipated.

4.2 This test method is not intended to predict viscosity loss 
field service for different polymer classes or for different 
field equipment. Some correlation for a specific polymer type 
in specific field equipment can be possible.

5. Apparatus

5.1 The apparatus consists of two fluid reservoirs, a single-

plunger diesel fuel injection pump with an electric motor drive, 
a pintle-type fuel injection nozzle installed in a nozzle holder, 
and instrumentation for automatic operation. Annex A1 con-
tains a more complete description of the apparatus.⁴ ⁵

6. Reference Fluids

6.1 Diesel fuel is required for adjusting the nozzle valve 
assembly to the prescribed valve opening pressure.

6.2 Calibration fluid TL-11074⁶ is used to verify that the 
shooting severity of the apparatus is within the prescribed 
limits.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³ Withdrawn.

⁴ The sole source of supply of the entire apparatus and spare parts (injectors) known to the committee at this time is Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL 60554.

⁵ If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consider-
ation at a meeting of the responsible technical committee ¹, which you may attend.

⁶ The sole source of supply of the apparatus known to the committee at this time is Tannas Co., 4800 James Savage Rd., Midland, MI 48642.

* A Summary of Changes section appears at the end of this standard.

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7. Precautions

7.1 During operation, the line between the pump and the nozzle holder is under high pressure. The safety shield should be in place when the apparatus is running. Stop the apparatus before tightening any fitting that is not properly sealed.

7.2 During operation and during the setting of the valve opening pressure, the fluid is discharged from the nozzle at high velocity and can inflict a serious wound if it strikes a part of the human body. Therefore, secure the nozzle assembly in position before the test apparatus is started. Similarly, take care to shield the operator from the nozzle discharge during the pressure-setting step.

8. Sampling

8.1 The test fluid shall be at room temperature, uniform in appearance and free of any visible insoluble material prior to placing in the test equipment.

8.2 After the test fluid has completed its twentieth cycle through the apparatus, drain it into a bottle for transfer to the kinematic viscosity measurement.

9. Calibration

9.1 Set the valve opening pressure of the diesel injector nozzle assembly to 20.7 ± 0.35 MPa (3000 ± 50 psi) by means of a hand-actuated pump and diesel fuel.

9.2 Set the delivery rate of the pump to 534 ± 12 cm³/min by the procedure described in Annex A1.

9.3 Verify the shearing severity of the apparatus by running the standard test procedure, described in 9.3.1, with reference oil. Make this check every twentieth run when the apparatus is used frequently. Make this check before any other samples are tested if the apparatus has been idle for a week or more. The kinematic viscosity at 100°C for the sheared reference oil is to be within the limits prescribed for the specific batch of the reference oil in use. For oil TL-11074, the limits are 9.64 and 9.94 mm²/s (cSt) at 100°C.

9.3.1 If the viscosity of the sheared oil does not fall within the above limits, make another shear test of the reference oil by the standard procedure. If the viscosity of the sheared oil still does not fall within the limits, take steps to correct the rating level of the test. Either mechanical difficulty or test technique is at fault.

10. Procedure

10.1 Shearing is accomplished by pumping the entire 100 cm³ test oil charge through the nozzle in successive passes or cycles. One cycle consists of pumping the oil from the lower reservoir (8) in Fig. A1.1, through the nozzle (5), and into the upper reservoir (6). At the end of each cycle, when the entire test oil charge has been collected in the upper reservoir (6), the pump (2) stops and the solenoid-operated drain valve (7) opens, draining the oil into the lower reservoir (8). The pump then restarts automatically for the next cycle. This process repeats for the number of cycles that have been set on the cycle counter. At the end of the last cycle, both solenoid-operated drain valves, (7) and (9) in Fig. A1.1, open and the test oil drains into the sample collection bottle (10).

10.2 Flush the apparatus with three separate 100 cm³ portions of the test oil as described in 10.2.1 and drain. Do not use solvent as part of the flush at any time because it could cause contamination.

10.2.1 Pour the first 100 cm³ charge of test oil into the lower reservoir, (8) in Fig. A1.1, through the funnel (14). Set the cycle counter for three cycles of the fluid through the nozzle, the pump timer for 15 s and the valve time for 20 s.

NOTE 3—These timer settings have been found satisfactory for all oils normally tested. The pump time should be sufficient for all oil to be pumped through the nozzle and into the upper reservoir, (6) in Fig. A1.1. The valve time should be sufficient for the oil to drain completely from the upper reservoir to the lower reservoir.

10.2.2 Start the pump, (2) in Fig. A1.1, and run until three cycles have been completed. Drain and discard the sheared oil.

10.2.3 Similarly, run the second 100 cm³ for two cycles and the third 100 cm³ flush for one cycle, draining and discarding each flush.

10.3 Pour 100 cm³ of the test oil into the lower reservoir through the funnel. Set the cycle counter for 20 cycles. Set a clean 120 cm³ (4 oz) bottle, (10) in Fig. A1.1, under the drain tube of the lower reservoir to receive the sheared sample. Start the pump and run until the 20 cycles have been completed. At the end of the twentieth cycle, both drain valves, (7) and (9) in Fig. A1.1, open automatically and the sample drains into the collection bottle, (10).

10.4 Measure the kinematic viscosity of the sheared oil and a sample of the unsheared oil at 100°C by Test Method D 445.

11. Calculation

11.1 Calculate the percentage loss of viscosity of the sheared oil as follows:

\[ \% VL = 100 \times (V_u - V_s)/V_u \]  

(1)

where:

\( VL \) = viscosity loss, %.

\( V_u \) = kinematic viscosity of unsheared oil at 100°C, mm²/s (cSt), and

\( V_s \) = kinematic viscosity of sheared oil at 100°C, mm²/s (cSt).

12. Report

12.1 Report the following information:

12.1.1 Percentage viscosity loss as calculated in 11.1.

12.1.2 Kinematic viscosity of the unsheared oil at 100°C.

12.1.3 Kinematic viscosity of the sheared oil at 100°C.

12.1.4 Number of cycles.

12.1.5 For reference oil runs, the batch number of the reference oil, and

12.1.6 Specify this test method (ASTM D5275).
13. Precision and Bias

13.1 The following criteria should be used for judging the acceptability of results:

13.1.1 Repeatability—The difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed the following value only in one case in twenty: 1.19 %.

13.1.2 Reproducibility—The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material would, in the long run, and in the normal and correct operation of the test method, exceed the following value only in one case in twenty: 5.22 %.

NOTE 4—The indicated repeatability and reproducibility values represent the subtractive difference between the reported percentage viscosity loss values for the two determinations being compared.

13.1.3 Bias—All test results are relative to those of Calibration Fluid TL-11074. Therefore no estimate of bias can be justified.

14. Keywords

14.1 fuel injector; polymer containing fluids; VII; shear stability

ANNEXES

(Mandatory Information)

A1. DETAILS OF FUEL INJECTOR SHEAR STABILITY TEST (FISST)

A1.1 Apparatus:

A1.1.1 Fig. A1.1 shows the test schematically. A cycle counter, pump timer, valve timer, main power switch, and drain valve switch are mounted on an instrument panel not shown in Fig. A1.1.

A1.1.2 Specifications for the Fuel Injection Parts:

Note A1.1—The parts have not changed; only the parts supplier and part number have changed. Previous parts may be used until supply is exhausted.

A1.1.2.1 Diesel Fuel Injection Pump ((2) in Fig. A1.1), Waukesha pump 106712G that contains: Plunger and barrel assembly, 8.0 mm, PPK 1/2ZG ((17) in Fig. A1.2), camshaft, 6/1, PAC 26/1X ((34) in Fig. A1.2), delivery valve assembly, 6.0 mm cuffless, PVE 67/1Z ((16) in Fig. A1.2), plunger spring SP 769 CA ((31) in Fig. A1.1), and tappet assembly TP 7615-1A ((19) in Fig. A1.1).

A1.1.2.2 Nozzle Holder, ((4) in Fig. A1.1), Waukesha P/N 110743.
A1.2 Method for Setting Injection Pump Rack:

A1.2.1 Preparation:

A1.2.1.1 Remove delivery valve holder (12) (numbers in parentheses refer to Fig. A1.2). Leave the body of the delivery valve (16) in place, but remove the internal check. Leave the delivery valve gasket (15) in place. The top of the pump plunger will be visible through the bore of the delivery valve body.

A1.2.1.2 Turn pump shaft (34), watching the top of the plunger (17) through the bore of the delivery valve body, until the plunger is at the bottom of its stroke.

A1.2.1.3 Insert a rod 4 mm (0.158 in.) in diameter by 40 mm (1.575 in.) or longer down through the open delivery valve body (16) and measure how high it stands above the top of the pump housing (1) to the nearest 0.50 mm (0.020 in.).

A1.2.1.4 Rotate the pump shaft until the rod moves upward 5 mm (0.197 in.). Mark the pump shaft or coupling so that it can be reset to this position again later.

A1.2.1.5 Taper one end of a length of stiff plastic translucent tubing (for example, 6.4 mm (0.252 in.) in diameter by 130 mm (5.118 in.) long nylon). Force the tapered end into the body of the delivery valve (16). Attach to it a 200-mm (7.874 in.) length of 8 mm (0.315 in.) diameter flexible tubing.

A1.2.1.6 Put sufficient light oil (such as a 4 to 5 mm²/s (cSt) at 100°C neutral oil) in the reservoir to cover the inlet to the pump (26). Turn the pump shaft as necessary to let oil rise in the nylon tube at the delivery valve.

A1.2.1.7 Set the control rack (27) at about two-thirds full open position (rack moved away from coupling).

A1.2.1.8 Set pump shaft or coupling at the position established in A1.2.1.4.

A1.2.1.9 Blow into or apply light air pressure to the tube attached to the delivery valve. The oil level in the translucent tube should not change.

A1.2.2 Adjustment:

A1.2.2.1 Open the rack ((27) in Fig. A1.2) slowly until the oil level in the nylon tube begins to drop. This rack position will correspond to the uncovering of the fill port by the vertical portion of the plunger grooving. It may be necessary to reset the position of the segment gear ((28) in Fig. A1.2) relative to the control sleeve ((29) in Fig. A1.2) to allow the pump plunger to rotate far enough to uncover the fill port. The segment gear
((28) in Fig. A1.2) is mounted concentrically on the control sleeve (29 in Fig. A1.2) and is locked in place by a clamping screw ((39) in Fig. A1.2). Loosening the clamping screw allows the segment gear to be rotated to the desired position on the control sleeve.

A1.2.2.2 Note the position on the rack adjusting screw where the fill port becomes uncovered.

A1.2.2.3 Return the rack ((27) in Fig. A1.2) 4.4 mm (0.175 in.) toward its closed position (move 3½ turns of SAE ¼-20 screw or 3½ turns of 1.25-pitch metric screw). This position should leave about 1.77-mm (0.07-in.) distance between the edge of the fill port and edge of the vertical groove on the pump plunger.

A1.2.2.4 Lock the pump control rack ((11) in Fig. A1.1) in this position by means of the rack adjustment screw ((12) in Fig. A1.1) and its two lock nuts. The rack spring ((13) in Fig. A1.1) will hold the rack against the adjustment screw.

A1.2.2.5 Remove standpipe and drain fluid from pump gallery.

A1.2.2.6 Reassemble delivery valve and connect pintle nozzle.

A1.2.6 Analysis of variance calculations for the two test methods with the combined ten engine oils and six hydraulic fluids was carried out on viscosity loss data at 100°C to compare test severity of the two test methods. They were found to be equivalent, with a correlation coefficient of 0.982. With X as Test Method D 3945 and Y as this test method, the correlation equation was 

\[ Y = 0.15 + 0.987X \]

A2.2 At the time of the precision study, two distinct test procedures were used. Data was developed using the European Diesel Injector Test in Test Method D 3945 (formerly Procedure A of Test Methods D 3945) and this test method (FISST method) (formerly Procedure B in Test Method D 3945).

A2.3 The precision indicated in Section 13 for this test method represents the largest data block, ten polymer containing engine oils tested by six laboratories after correction for outliers at a 1% significance screening level.

A2.4 The precision for this test method of 1.19% viscosity loss repeatability and 5.22% viscosity loss reproducibility compares to European Diesel Injector Test precision of 1.43% and 4.57% respectively in Test Method D 3945. In either test method, precision for hydraulic type fluids is lower than indicated in the precision statement.

A2.5 Subsequent investigation9 has shown that the two test methods give different results with certain polymers or when the number of test cycles are significantly increased. Under these conditions, European Diesel Injector Test in Test Method D 3945 tends to be more severe.

A2.7 The significance statement clearly indicates that it is not intended that this test method serve to predict the performance of polymer-containing fluids in service. This conclusion is based on regression analysis of data by the European Diesel Injector Test in Test Method D 3945 compared to available (limited statistical basis) field data for the test oils. Although a specific correlation between this test method and the field data was not attempted, the correlation between the two test methods shown in A2.5 would support a statement that this test method does not correlate with field data for the test oils.

SUMMARY OF CHANGES

Subcommittee D02.07 has identified the location of selected changes to this standard since the last issue (D 5275–92 (1998)e1) that may impact the use of this standard.

(1) Modified Footnote 6 and Paragraph 6.2 to reflect a different supplier of the reference oil.

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